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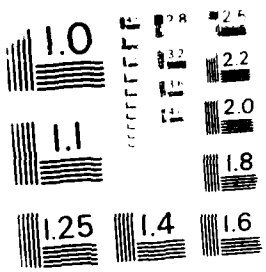
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AD-A191 037

Aircraft Structures Technical Memorandum 475

PAFEC LEVEL 8.2 APPLICATION PROGRAMS

by

J. PAUL

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PAFEC LEVEL 6.2 APPLICATION PROGRAMS

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SUMMARY

Finite element programs such as PAFEC often produce vast quantities of data which need to be processed. For analysis purposes only certain information is required and the rest is often discarded. However, the massive amounts of output generated sometimes makes it difficult to locate the relevant information. This report provides a brief outline of a suite of programs which have been developed for use with PAFEC to enable easier processing of the relevant data.

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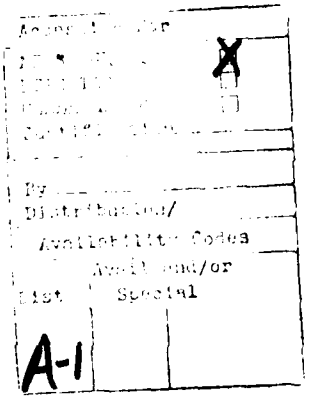
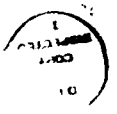




1. INTRODUCTION

Finite element programs generate vast amounts of numerical data. This set of data has to be processed by the user to obtain the required information about a particular numerical model or process results, e.g. find crack tip nodes or stresses around a crack tip. The purpose of the suite of programs presented in this report is to simplify the processing of this information.

The PAFEC finite element package provides the programmer with a suite of subroutines that allow access to the data held in the PAFEC database. Using these subroutines such programs can be written to manipulate sections of the database in the required way.

The suite of programs presented in this report are divided into two distinct sections. The first section discusses those programs which enable the user to access and modify the data held. With some programs the modified information can be stored into the database. The second section deals with the post processing of results. In some cases the output from the first section can be used as the input to the post processing programs.

The purpose of this report is to provide a brief outline of each of the application programs currently available. The execution of the programs is simplified by the fact that they are interactive, i.e., the programs prompt the user for the required information. There exists a fairly high degree of error trapping which allows recovery if the incorrect data are entered. However there is always the contingency that the user will have to start from scratch.

2. ACCESSING PAFEC PROGRAMS

Executable versions of the application programs can be accessed by users on the ELXSI computer at the Aeronautical Research Laboratories (ARL). The path name of the area is as follows:

/Applications/Fe packages/pafec/pafec

To access these files aliases are created in the users command directory pointing to the particular file on the PAFEC area. It is envisaged that with future levels of PAFEC this will be changed and will require the user to modify their command search rule to access the PAFEC commands directory. At present a shellfile (i.e., an executable command language file) on the PAFEC area, which is called PAFEC-SET-UP, automatically assigns all the relevant aliases for the user. It also sets up the the users command directory so that they can execute PAFEC.

3. PROGRAM DESCRIPTIONS

3.1 PROGRAMS FOR MODEL MANIPULATION

3.1.1 Program name: NODEFIND

Description: The NODEFIND program is used to extract node numbers and their co-ordinates. The menu provided allows the easy selection of a multitude of search patterns. The tolerances in searching the nodal co-ordinates can be changed to adjust for numerical errors in the co-ordinate value. Nodes can be read from an external file if the procedure has to be repeated many times.

Output file name: [Jobname].NODES

Output description:
Pafec job name
Tolerance used
Description of option chosen
Node, X, Y, Z, Radius, Theta (relative to input node)
Data.

3.1.2 Program name: PAFGRFIND

Description: Element data in a finite element program is made up of group numbers, property numbers and nodal topology. PAFGRFIND is used to extract this set of data. There are two options, one which allows the input of a node number and the other which requires the element number.

Output file name: [Jobname].GRFIND

Output description:
Pafec job name
Option description
Node, element, group, element type, property numbers
Data.
or
Element, group, property numbers and topology
Data.

3.1.3 Program name: PAFINFO

Description: PAFEC stores information about the structure in an array called IBASE. This program displays the information outlined in the output description section and can be very useful in extracting information pertaining to a particular backing store file.

Output file name: [Jobname].INFO

Output description:
Current phase indicator.
Nodal information.
Job tolerance.
Element information.
Number of degrees of freedom.
Dimension of stiffness matrix.
Plane stress or plane strain.
Error and warning count for the current phase.

3.1.4 Program name: PAFTRIM

Description: This program allows the extraction of elements with their corresponding nodes from a PAFEC backing store. The nodes extracted can be renumbered from 1 if required. PAFTRIM can be used to extract a substructure from a much larger model. It can also be used to check if elements have collapsed. The output file is written as a PAFEC data file with only nodal and elemental data.

Output file name: [Jobname].TRIM

Output description:
Pafec phase 1 control module
Nodes module header
Data
Elements module header
Data.
END OF DATA card

3.1.5	Program name	PAFCENTROID
	Description	This program calculates the centroids of all elements in the structure and with the provided search information it outputs the element numbers found. This is then used in conjunction with PAFGRSET (see 3.1.6) to set the group number of the elements to a group number not currently used. Then, when using PIG (Pafec Integrated Graphics System), the selected group can be drawn, thereby allowing slices of the structure to be drawn.
	Output file name	[Jobname] CENT
	Output description	Element, X, Y, Z centroidal coordinates, Radius, Theta Data List of elements for PAFGRSET input Data

3.1.6	Program name	PAFGRSET
	Description	*This program changes the group number of the elements listed* in an input file to the required group number. The elements that are to have their group numbers changed must exist in a dummy file so that the program can access them. PAFGRSET can be used to change element group numbers in the backing store file and the job can be restarted with these modified groups being used in conjunction with an existing PAFEC input module. This is useful if the numerical model was pafblock generated.
	Output file name	[Jobname] BS (MODIFIED)
	Output description	None
		WARNING It should be noted that this program modifies the backing store file and might, in some instances, not allow the successful restart of a problem. Therefore great care must be taken when using this program.

3.1.7	Program name	ENQIBASE
	Description	When writing PAFEC code it is very useful to know the values of certain PAFEC control and structural constants. This program allows the programmer to examine the value of any IBASE number. IBASE is the PAFEC array that holds these control and structural constants.
	Output file name	None (Output is to the terminal)
	Output description	IBASE number and value

3.1.8	Program name	GAPS
	Description	Locating the GAPS and CRACK TIP [illegible] sional problem can be [illegible] GAPS program will [illegible] the crack tip [illegible] The crack front [illegible] ified if required. The GAPS [illegible] two dimensional problems.

	Output file names	[Jobname] GAPS [Jobname] GAPINFO
	Output description	
	[Jobname] GAPS	Gaps module header Data Crack tip module header Data
	[Jobname] GAPINFO	Paired gap nodes NODE, X, Y, Z coordinates, Radius, Theta Data
3.4.9	Program name	SCAL
	Description	In some problems, especially with composite materials, where the aspect ratio of elements is sometimes very large, [illegible] structure in PIGS is difficult. SCAL allows the user to scale up or down the X, Y or Z coordinates by a factor thereby [illegible] a clearer view of the structure.
	Output file name	[Jobname] BS (MODIFIED)
	Output description	None
		WARNING It should be noted that this program modifies the backing store file and might not allow a successful restart of a problem. SCAL can be used in reverse to return the backing store coordinates to their original values, but care must be taken.
3.4.10	Program name	DELAMINATION
	Description	This program will create a near complete PAFEC data file with a hole and a circular delamination at the specified layer in the composite. The output file has a complete list and description of all the parameters used. The program will need to be recompiled if these parameters are changed. DELAMINATION can create a structural model with or without the delamination and with or without a patch on the top surface.
	Output file name	Requested at run time
	Output description	See created output file for full description of parameters and the PAFEC modules to be checked.
3.4.11	Program name	NODEFQIV
	Description	Sometimes two data files with the same structure but differently meshed need to be compared. The [illegible] of the structure often causes allocated [illegible] NODEFQIV compares two [illegible] equivalent [illegible] from a dummy file [illegible]
	Output file name	[Jobname] FQIV [illegible]
	Output description	First jobname second jobname X, Y, Z [illegible] Data

3.2 POST PROCESSING PROGRAMS

3.2.1	Program name	PAFSTRESS
	Description	For large finite element problems vast amounts of stress output can be generated. PAFSTRESS is designed to condense this output to a manageable quantity. The program provides the ability to extract nodal or elemental averaged or unaveraged stresses. The elemental global stresses are displayed when the unaveraged option is selected and the principal stresses are provided when the averaged option is chosen. Output to the terminal is limited but all information is written to the output file. PAFSTRESS accesses two files: the first is the backing store and the second is called the SS file. The backing store provides the ability to check the requested node or element number with that in the structure and provide the program with the [illegible] of the requested element. The SS file provides the stress information and is accessed through a slightly modified PAFEC version of the routine R70000 (see PAFEC Data Preparation User Manual, Level 6.2, section 7.12.5).
	Output file name	[Jobname] STRESS
	Output description	Pafec job name Option description Element, node σ_1 σ_2 σ_3 σ_4 [illegible] or Element, node σ_1 σ_2 σ_3 σ_4 σ_5 σ_6 [illegible]
	Note 1	There exists in the PAFEC code a program bug which causes the stress records to be written to the SS file. This hopefully will be corrected in PAFEC level 7. Due to this bug PAFSTRESS will sometimes print duplicate information for a particular node.
	Note 2	Initially on using PAFSTRESS it is advisable to compare phase 5 output with the output from PAFSTRESS. If a difference occurs then ignore the PAFSTRESS output as the SS file could somehow have become corrupt.
	Note 3	PAFSTRESS will only produce stresses for the [illegible] in the PAFEC STRESS ELEMENT module.

3.2.2	Program name	DISPL
	Description	The PAFEC phase 7 calculates all the elastic displacements for the numerical model. DISPL can be used to extract any nodal displacement required. If more than one load case is present then the program will automatically recognize this and prompt for the load case required. The program can also be used to check the status of gaps nodes and this comes under the option of nodal pairs differenced.
	Output file name	[Jobname] DISPL
	Output description	Pafec job name Node Ux Uy Uz displacement or Node Ux Uy Uz displacement [illegible]

3.2.3 Program name: **PLASDISPL**

Description: The displacements for a PAFEC plasticity analysis are not stored for each load increment due to the amount of storage space required. If the displacements are required at each of the load increments then modifications are required to the data file and to the PAFEC code. These modifications are outlined below and result in the displacements being stored in a binary file. After the analysis has been completed, PLASDISPL can then be executed to extract the displacements at any load increment from the [jobname].DISP.

Output file name: None

Output description: Node, Ux, Uy, Uz displacements to terminal.

Data file changes: The following lines should be inserted after the PHASE statement in the control module:

```
USE PLASJINT
ADD PROG.
        CALL R09806(6,ML6,JROW,IPO6)
        IREC = ML6 * 4
        OPEN(UNIT = 79,FILE = [JOBNAME].DISP
      + FORM='UNFORMATTED',ACCESS='DIRECT'
      + RECL=IREC,STATUS='NEW')
END.OF.ADD.PROG
```

PAFEC code changes: Insert the following lines in routine INCIDIS in PLASJINT.1 before the return statement:

```
IDCHAN = 79
CALL R00401(IDCHAN,INCT,BASE(IPO6),LM6,2)
```

3.2.4 Program name: **PAFSTRAIN**

Description: The program PAFSTRAIN can be used to extract the strain values for nodes and elements in exactly the same manner as PAFSTRESS (see 3.2.1). The program accesses the ET file, in which PAFEC has written the strain records. The ET file is only written if the user has requested a non-linear analysis. This file is usually deleted after completion of the analysis by the PAFEC shell commands. If required by any user then the control module option of SAVE.ET.FILE should be used in control module.

Output file name: [Jobname].STRAIN

Output description:

Pafec job name
Option description
Element or node number
Load case, Group, Element, Node [illegible]
or
Load case, Node [illegible]

3.2.5 Program name: **PAFSTRCAL**

Description: Sometimes it is desirable to calculate the strains through certain sections of the structure. PAFSTRCAL will calculate the strains using the following formulas:

$$\frac{U_1 - U_2}{\Delta l}$$

where U_1, U_2 are the displacements of the two points in the x, y or z direction and Δl is the distance between the two points in the x, y or z direction. The program requests the direction of the line and then a node on the line. Only the corner nodes that exist on the line are used in the above formula.

Output file name: Jobname STRCAL

Output description:
Tolerance
Node (x, y or z coordinate), (x, y or z difference), (U_x, U_y or U_z), (U_x, U_y or U_z difference)
Paired data

3.2.6 Program name: ENERGY

Description: Failure analysis of composite material involves the calculation of a number of parameters such as the strain energy density, volume fraction ($\varepsilon_1 + \varepsilon_2 + \varepsilon_3$) and area fraction. ENERGY accesses the backing store file and the SS file to retrieve the stresses and strains for orthotropic material elements only. To examine a particular point in the structure the node and element number is required. If the element number is given as zero, the program will provide a list of elements attached to that node number.

Output file name: [Jobname] ENERGY

Output description:
Pafec job name
Node, Element, σ_1, σ_2, σ_3, [illegible]

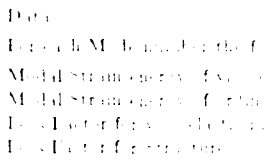
Data
Total energy
Available energy
DV
DA1
DA2
DA3
Message depicting whether DV/DA1, DV/DA2 or DV/DA3 is the maximum

3.2.7 Program name: MODAL

Description: Analysing a viscoelastic material using the PAFEC dynamic analysis, involves determining the modal strain energy for each element and for each mode shape. PAFEC produces tables of strain energy, but it is convenient to manipulate these tables in terms of the elements defined as viscoelastic. The MODAL program calculates the strain energy for each element and mode and assumes that the viscoelastic elements are defined as group 1 in the numerical model. The loss factor for the viscoelastic elements is assumed to be 1. To be able to execute MODAL the elemental stiffness file (FS file) must not be deleted at the end of the run. To stop the PAFEC shell command from deleting the file, the option SAVE FS FILE must be included in the control module.

Output file name: Jobname MODAL

Output description:
Title
Element, Mode 1, Mode 2, ..., Mode 10
Data
Element, Mode 11, Mode 12, ...



4. DISCUSSION

The suite of programs outlined in this report are useful tools in analysing PATRAN models. The programs allow repetitive work to be carried out with the minimum effort. They do not take away the need for the user to check information and if doubt occurs check all PATRAN output should generally be believed before the output from the particular program. As mentioned earlier, extensive error trapping is performed, but sometimes the path through the program that the user takes may cause a problem to arise.

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16 ABSTRACT

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